MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EEE 7236 – POWER ELECTRONICS AND ELECTRICAL MACHINES

12 MARCH 2016
2:30 P.M. – 5:30 P.M.
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages including cover page with 4 Questions only.
2. Answer ALL questions. The distributions of the marks for each question are as stated.
3. Please write all your answers in the Answer Booklet provided.

Question 1

A. Table 1 depicts characteristics of some power electronic devices. Select a suitable power transistor for a DC-DC converter with proper justification. The specification for the converter are given as:

Input dc voltage: 250V, output voltage: 200V, Maximum output current: 100A. The size of the converter is to be kept to minimum possible.

Table 1

Switch Type	Base/Gate Control Variable	Control Characteristic	Switching Frequency	On-State Voltage Drop	Max. Voltage Rating V_s	Max. Current Rating I_s
BJT	Current	Continuous	Medium 20 kHz	Low	1.5 kV $S_s = V_s I_s$ = 1.5 MVA	1 kA $S_s = V_s I_s$ = 1.5 MVA
MOSFET	Voltage	Continuous	Very high	High	1 kV $S_s = V_s I_s$ = 0.1 MVA	150 A $S_s = V_s I_s$ = 0.1 MVA
IGBT	Voltage	Continuous	High	Medium	3.5 kV $S_s = V_s I_s$ = 1.5 MVA	2 kA $S_s = V_s I_s$ = 1.5 MVA

[7 Marks]

Continued…

B. You have to design a power electronic converter. In selecting the components for the converter, explain the influence of the following factors in the selection process.

(a) On-state resistance
(b) Switching time
(c) Voltage and current ratings
(d) Device cost

[4 x 2 Marks]

C. With suitable diagrams, explain the operation of a separately excited DC motor drive that is powered from a 3-phase supply through controlled rectifiers. Highlight the control necessary for regenerative braking.

[10 Marks]

Question 2

(a) Draw schematic diagrams of (i) 12-pulse and (ii) 6-pulse controlled rectifier circuits for HVDC power transmission. Comment on the transformer connection of 12-pulse supply.

[15 Marks]

(b) Design a Boost dc to dc converter that can generate an output voltage of 48 V from an input voltage of 12 V with a ripple of less than 1% in the output voltage across a load of R = 20 Ω. The converter circuit should be designed for the continuous current operation at a switching frequency of 20 kHz. Determine the:

i) duty ratio [2 Marks]
ii) size and voltage rating of the inductor [5 Marks]
iii) size and voltage rating of the capacitor [3 Marks]

Assume all component used are ideal.

Question 3

(a) A 3-phase, 50 Hz, 10 hp, 400 V, 6 pole, delta-connected induction motor has full load efficiency and power factor of 0.9 and 0.8 lagging respectively. The motor is connected across a balanced 400 V, 3-phase supply. How the motor works when one phase of the power supply fuse burns out, while the motor is (i) starting and (ii) running at full load?

[4 Marks]

Continued...

(b) Design a circuit using a 3-phase zigzag transformer such that the motor in Q3(a) works satisfactorily under all conditions, while one phase of supply remains open. Draw a circuit diagram showing the current distribution in the motor and zigzag transformer windings at full load. [15 Marks]

(c) The no load speed of a 90-V permanent magnet dc motor is 375 rad/s. The resistance of the armature circuit is 1.2 Ω. The load on the motor is 4 Nm. The motor maintains constant magnetic flux with no rotational losses. (i) Calculate the motor speed when the input voltage is 60 V and 90 V. [6 Marks]

Question 4

(a) State the conditions required for applying regenerative breaking in a DC motor. Suggest some modifications in the series field connection of a cumulative compound DC motor for successful operation during regenerative breaking. [6 Marks]

(b) A 10 kW, 600 V, cumulative compound dc traction motor is running at 1000 rpm at full load. Regenerative braking is applied to the motor when it speeds up running down a slope. If 10 kW power is fed back to the system, estimate the speed of the motor. Resistances of armature, series and shunt fields are 0.15 Ω, 0.25 Ω and 600 Ω respectively. At full load with 1000 rpm speed series field flux is 10% of total flux. [5 Marks]

(c) With a suitable diagram, design a circuit for using 3-phase wound rotor induction motor to be used as high torque stepper motor. [4Marks]

(d) A 3-phase stepper motor required for one particular application must be capable of stepping in 10^{o} interval, and it must be capable of running at 600 rpm.

(i) How many poles must this motor have? [1 Mark]

(ii) How many pulses per second must be applied to the control circuit? [1 Mark]

(iii) Construct a table showing step size versus number of poles for three-phase and four-phase stepper motors. [3 Marks]

(e) With suitable diagrams, write short note on the rotor structure of a Brush-Less Direct Current (BLDC) motor. [5 Marks]

End of Paper